# Intraprocedural Angiographic CT as a Valuable Tool in the Course of Endovascular Treatment of Direct Sinus Cavernous Fistulas

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## Summary

*This investigation aimed to demonstrate the potential of intraprocedural angiographic CT in monitoring complex endovascular coil embolization of direct carotid cavernous fistulas.*

*Angiographic CT was performed as a dual rotational 5 s run with intraarterial contrast medium injection in two patients during endovascular coil embolization of direct carotid cavernous fistulas. Intraprocedural angiographic CT was considered helpful if conventional 2D series were not conclusive concerning coil position or if a precise delineation of the parent artery was impossible due to a complex anatomy or overlying coil material. During postprocessing multiplanar reformatted and dual volume images of angiographic CT were reconstructed.*

*Angiographic CT turned out to be superior in the intraprocedural visualization of accidental coil migration into the parent artery where conventional 2D-DSA series failed to reliably detect coil protrusion. The delineation of coil protrusion by angiographic CT allowed immediate correct coil repositioning to prevent parent artery compromising.*

*Angiographic CT can function as a valuable intraprocedurally feasible tool during complex coil embolizations of direct carotid cavernous fistulas. It allows the precise visualization of the cerebral vasculature and any accidental coil protrusion can be determined accurately in cases where conventional 2D-DSA series are unclear or compromised. Thus angiographic CT might contribute substantially to reduce procedural complications and to increase safety in the management of endovascular treatment of direct carotid cavernous fistulas.*

## Introduction

Direct carotid cavernous fistulas (DCCFs) are pathological shunts between the internal carotid artery and the cavernous sinus. In 0.2-0.3% of craniofacial traumata [1] they occur as a sequela of traumatic laceration of the vessel wall of the intracavernous internal carotid artery (ICA). According to Barrow these DCCFs are classified as type A fistulas [2]. The goal of treatment, mostly by an endovascular approach, is the complete occlusion of the fistula ideally while preserving the patency of the ICA. Various endovascular techniques are described i.e. embolization with detachable balloons, coil embolization by transarterial or transvenous route, stent/balloon-assisted techniques or the use of covered stents. A successful endovascular treatment can be achieved in about 85% [3-6].

The coil embolization technique with electrolytically detachable coils is a well-established method for endovascular DDCF-treatment [7-10], but it may occur that an ideal 2D angiographic projection cannot be obtained during the intervention i.e. because of a complex anatomy, tortuous vessels at the cavernous segment or overlying embolization material. Subsequently, the vessel structures and the position of the coils cannot be delineated precisely and accidental coil dislocation into the parent artery might oc-

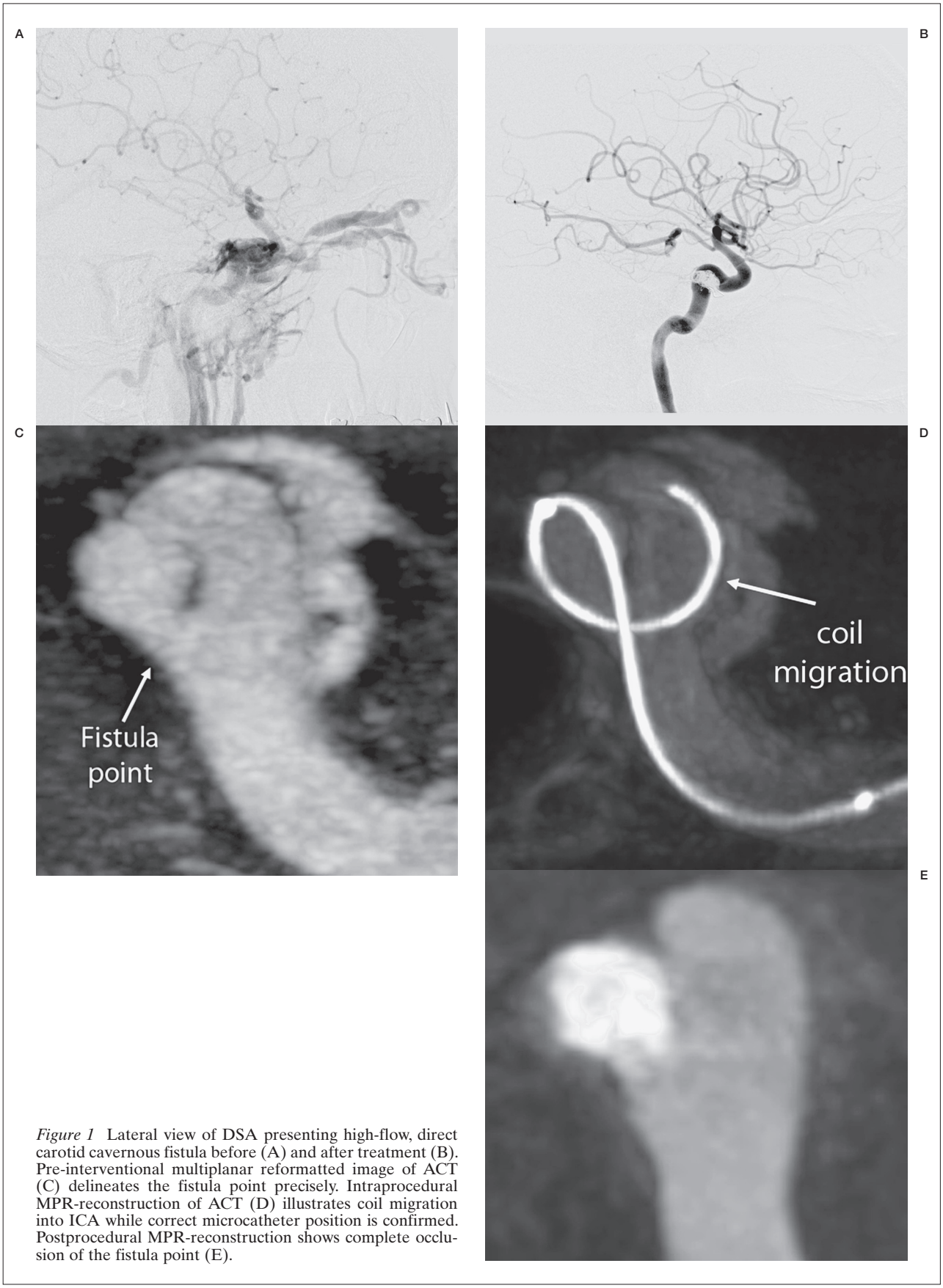
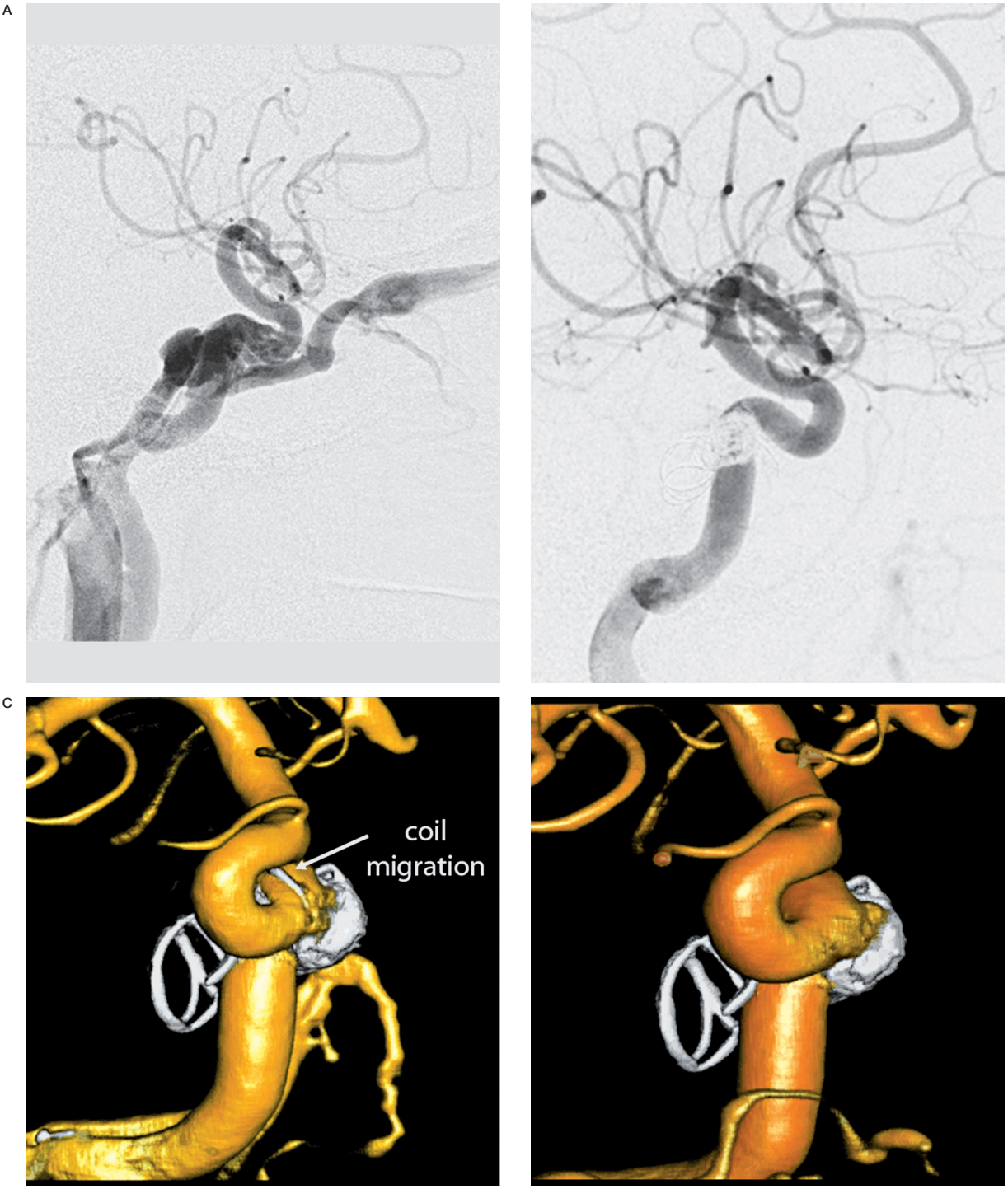



*Figure 1* Lateral view of DSA presenting high-flow, direct carotid cavernous fistula before (A) and after treatment (B). Pre-interventional multiplanar reformatted image of ACT (C) delineates the fistula point precisely. Intraprocedural MPR-reconstruction of ACT (D) illustrates coil migration into ICA while correct microcatheter position is confirmed. Postprocedural MPR-reconstruction shows complete occlusion of the fistula point (E).




cur. To prevent such complications angiographic CT (ACT) with intraarterial contrast medium injection can be used intraprocedurally within the angio suite. Flat panel detector technology allows the acquisition of high spatial resolution volumetric images with the option to create multiplanar reformatted and dual volume images for accurate visualization of coil position. At stent-assisted coil therapies ACT has already proven to be a reliable technique [11].


*Figure 2* Lateral view of DSA before (A) and after (B) coil embolization of DCCF. Intraprocedural ACT, reconstructed as dual volume (C) and multiplanar reformatted image (E), allows a clear delineation of coil protrusion into left ICA in contrast to the conventional 2D-series (G). After successful coil repositioning the patency of the ICA is demonstrated by dual volume (D) and multiplanar reformatted ACT images (F) as well as the correlating 2D-series (H).

We here present two cases where intraprocedural ACT revealed accidental coil migration into the ICA during endovascular treatment of DCCFs while conventional angiographic 2D-series were not conclusive.

## Patients and Methods

Two patients presenting typical clinical symptoms of a carotid cavernous fistula were treated transarterially in general anesthesia by an endovascular approach. During the interventional procedure ACT with intraarterial contrast material injection was performed.

### *Intraprocedural angiographic CT*

ACT imaging was performed on a biplane flat panel detector angiographic system (Axiom Artis dBA; Siemens AG, Healthcare Sector, Forchheim, Germany). The 3D dual rotational angiography was generated by using the standard parameters as provided by the manufacturer (5 s run, Siemens AG, Healthcare Sector, Forchheim, Germany) with selective, 4-mL/s injection via the ICA using a power injector (MEDTRON, Saarbruecken, Germany). Such a 5 s run requires about 15-20 ml of contrast material (Imeron 300, Bracco Imaging, Konstanz, Germany).

### *Postprocessing*

The angiographic data were transferred to the connected workstation (Leonardo, Siemens AG, Healthcare Sector, Forchheim, Germany). Beam hardening, ring artifacts and scattered radiation were corrected automatically. Image reconstructions were performed by using commercially available software (Dyna-CT, InSpace 3D software, Siemens AG, Healthcare Sector, Forchheim, Germany). The mode "native fill", kernel type "HU" and image impression "normal" were chosen for image characteristics. Then the images were loaded into the 3D function of the workstation and multiplanar reformattings were done. Next, image reconstructions were performed with the following parameters: mode "native mask", kernel type "HU", image impression "sharp" as well as mode "native mask", kernel type "EE" and image impression "smooth". These reconstructed images were fused and loaded into the InSpace function of the workstation (dual-volume imaging technique). The image reconstructions are displayed simultaneously on a monitor within the angio suite rendering patient transfer unnecessary.

## Case Reports

### *Case 1*

A 61-year-old man developed progressive visual decline two months after a bicycle fall with consecutive fractures of the skull base. MRI and DSA demonstrated a direct, high-flow fistula between distal, left-sided ICA and sinus cavernous. The venous drainage followed via dilated superior ophthalmic veins, left inferior petrosal sinus and intercavernous sinus. The endovascular treatment was considered necessary. A 6F guiding catheter was placed by transfemoral route in the left ICA. A microcatheter was placed through the fistula point into the sinus cavernous. Then the first coil (GDC-2D 5×15 mm, Boston Scientific, Fremont, USA) was developed. Because 2D series could not clearly visualize correct coil position exclusively within the cavernous sinus, an ACT (5 s run) with intraarterial contrast medium injection was performed. The multiplanar reformatted images revealed coil migration into ICA, while the correct position of the microcatheter was confirmed (Figure 1). Subsequently the coil was repositioned successfully. Thereafter six more coils could be implemented without complications. After treatment the fistula was occluded completely. Angiographic follow-up after four months showed still complete occlusion. Within four years after intervention no recurrence of clinical symptoms had occurred.

### *Case 2*

A 50-year-old woman presented with chemosis of the right eye, diplopia and visual decline that had arisen five weeks before. Recent trauma was not recalled. MRI and subsequent DSA revealed a direct, high-flow fistula between distal, right-sided ICA and sinus cavernous. The venous drainage followed via the right inferior petrosal sinus and the right superior ophthalmic vein. The patient was scheduled for endovascular treatment. By a transfemoral approach a 6F guiding catheter was placed in the right ICA. Then with a microcatheter the fistula point was passed. After placement of three

coils (GDC-2D 6×20, 6×20, 5×15 mm, Boston Scientific, Fremont, USA) a fourth coil (GDC-2D 5×15 mm) was inserted. Because of overlying embolization material the 2D series was compromised concerning the precise delineation of coil position. Thus an ACT (5 s run) with intraarterial contrast medium injection was performed. The dual volume images revealed coil protrusion into ICA (Figure 2). Immediate coil repositioning was performed successfully. Thereafter the fistula was occluded completely. The clinical symptoms showed remarkable regression. Angiographic follow-up after four months still depicted complete occlusion and patency of the ICA. Within three years after intervention no recurrence of clinical symptoms was observed.

## Results

In both cases the acquisition of conventional angiographic 2D-DSA series and ACT with intraarterial contrast medium application was feasible. Intraprocedural ACT reliably revealed accidental coil migration into parent artery whereas the conventional angiographic 2D series failed. The option to reconstruct multiplanar reformations and dual volume images of the ACT allowed precise delineation of coil loops within the ICA. Solely 2D-DSA series were not sufficient to detect accidental coil protrusion and consecutive vessel narrowing. The delineation of coil protrusion by ACT allowed immediate correct coil repositioning to prevent procedural complications.

## Discussion

The treatment of direct carotid cavernous fistulas (DCCFs) with coil embolization has developed as a well established endovascular approach [7-10,12-14]. It offers the advantage of an easy handling and the chance to replace undetached coils if neccessary. On the other hand it harbours the risk of coil protrusion whereby the patency of the parent artery is threatened. To prevent such complications a precise delineation of the vascular structures as well as the developing coils is mandatory. Due to a complex anatomy or overlying embolization material the 2D angiographic series does not always allow a conclusive visualization of the vasculature. Here the newly implemented technique of angiographic CT (ACT) with its high spatial resolution could be helpful to get further, crucial information. ACT has already proven to be a reliable technique at stent-assisted coil therapies [11] and for identifying procedural complications like bleedings or infarctions [15].

We here describe two cases where ACT functioned as supporting, beneficial tool in the course of complex endovascular coil emobolization of DCCFs. The conventional angiographic 2D-DSA series were not able to delineate coil position reliably, while intraprocedural ACT illustrated clearly coil migration into the parent artery. ACT turned out to be superior to conventional angiographic 2D-DSA in monitoring the complex DCCF treatments since even small or "silent" protruded coil loops could be identified and repositioned immediately. Especially the option to reconstruct multiplanar reformatted and dual volume images of the ACT is extremely helpful within the acute interventional setting. As a major advantage it can be performed fast and easily within the angio suite and no patient transfer is necessary. The high spatial resolution of ACT leads to an optimized visualization of devices and vessel structures and thus the necessity of additional, protective stent deployment in the ICA during complex DCCF coil embolization might be avoided in certain cases.

Concerning the radiation dose internal investigations determined the effective dose of a 5 s ACT only slightly elevated compared to conventional biplane 2D series at a level of about 1.2 mSv (vs. 1 mSv). In relation to the diagnostic benefit this slightly elevated radiation dose seems acceptable, especially if intraprocedural ACT might reduce the total number of 2D series leading in consequence to an overall reduction of radiation dose. Moreover, a concomitant reduction of the required contrast medium can be obtained. From our investigations it might be recommended to use intraprocedural ACT frequently in complex endovascular treatments of DCCFs for timely recognition of accidental complications.

## Conclusion

Intraprocedural ACT can function as a valuable tool, rapidly applicable within the angio suite to visualize reliably accidental coil protrusion while complex endovascular treatment of direct carotid cavernous fistulas. Due to its high

spatial resolution ACT showed superiority to conventional angiographic 2D-DSA concerning the clear delineation of embolization material and the distinct visualization of vessel structures. The option to reconstruct muliplanar reformatted and dual volume images of ACT allows a precise assessment of coil position even with complex neuroendovascular procedures if conventional 2D-DSA series are limited. Thus intraprocedural ACT can contribute to reduce procedural complications resulting in increased patient safety.

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